IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Mei Chen
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Art Unit : 2624
Examiner : Smith, Jeffrey S
Confirmation No.: 8143

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APPEAL BRIEF

I. Real Party in Interest

The real party in interest is Hewlett-Packard Development Company, L.P., a Texas Limited Partnership having its principal place of business in Houston, Texas.

II. Related Appeals and Interferences

Appellant is not aware of any related appeals or interferences that will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

III. Status of Claims

Claims 1-55, which are the subject of this appeal, are pending.

Claims 1-55 stand rejected.

Appellant appeals all rejections of the pending claims 1-55.

IV. Status of Amendments

The amendments filed October 22, 2007, have been entered and acted upon by the Examiner.

No amendments were filed after the final Office action dated December 28, 2007.

V. Summary of Claimed Subject Matter

A. Independent claim 1

The aspect of the invention defined in independent claim 1 is a machine-implemented image processing method (see page 3, line 31 - page 4, line 15; page 5, lines 10-22). In accordance with this method, a respective motion map is computed for each pairing of a reference image and a respective image neighboring the reference image in a sequence of base images (see page 5, lines 12-14; FIG. 2A, block 19). Each motion map comprises a set of motion vectors mapping reference image pixels to respective neighboring image pixels (see page 5, lines 14-16). Respective regions of a target image are assigned to motion classes based on the computed motion maps (see page 5, lines 16-17; FIG. 2A, block 21). The target image has a target resolution level and the base images having a base resolution level equal to or lower than the target resolution level (see page 5, lines 17-19). Pixel values are computed for the target image based on corresponding pixel value contributions from the base images selected in accordance with the motion classes assigned to the target image regions (see page 5, lines 19-22; FIG. 2A, block 23).

B. Claim 3

Claim 3 depends from claim 1 and recites that assigning regions of the target image to motion classes comprises assigning pixels of the reference image to respective motion classes (page 10, lines 11-13; FIG. 2B, block 40) and up-projecting the motion class assignments to pixels of the target image (page 11, line 32 - page 12, line 2; FIG. 2B, block 62).

C. Claim 4

Claim 4 depends from claim 3 and recites that assigning reference image pixels to motion classes comprises computing motion magnitude maps from each motion map (page 10, lines 13-14; FIG. 7, block 42), down-sampling the computed motion magnitude maps to a pyramid of motion magnitude maps at respective resolution levels lower than the base resolution level (page 10, lines 17-19; FIG. 7, block 46), and segmenting pixels in the pyramid of down-sampled motion magnitude maps into motion classes (page 10, lines 20-21; FIG. 7, block 50).

D. Claim 6

Claim 6 depends from claim 3 and recites assigning reference image pixels to motion classes comprises generating a separate motion class segmentation map for each pairing of the reference image and a respective neighboring image and merging the separate motion class segmentation maps into a unified motion class segmentation map for the reference image (page 11, lines 13-15).

E. Claim 7

Claim 7 depends from claim 6 and recites that reference image pixels are respectively assigned to a motion class selected from a motion class set including a high motion class and a low motion class, and motion vectors assigned to the high motion class have higher magnitudes than motion vectors assigned to the low motion class (page 10, lines 21-25).

F. Claim 8

Claim 8 depends from claim 7 and recites that merging the separate motion class segmentation maps comprises assigning a given reference image pixel to the low motion class in the unified motion class segmentation map when the given pixel is assigned to the low motion class in all of the separate motion class segmentation maps (page 11, lines 15-19), and assigning a given reference image pixel to the high motion class in the unified motion class segmentation map when the given pixel is assigned to the high motion class in any of the separate motion class segmentation maps (page 11, lines 19-22).

G. Claim 10

Claim 10 depends from claim 9 and recites that merging the separate motion class segmentation maps comprises assigning a given reference image pixel to the intermediate motion class in the unified motion class segmentation map when the given pixel is unassigned to the high motion class in any of the separate motion class segmentation maps and is unassigned to the low motion class in all of the separate motion class segmentation maps (page 11, lines 22-31).

H. Claim 11

Claim 11 depends from claim 1 and recites computing an alignment accuracy map for each pairing of the reference image and a respective neighboring image based on the computed motion maps (page 10, lines 8-10).

I. Claim 13

Claim 13 depends from claim 11 and recites up-projecting the computed alignment accuracy maps from the base image resolution level to the target image resolution level (page 11, line 32 - page 12, line 2; FIG. 2B, block 62).

J. Claim 16

Claim 16 depend from claim 1 and recites up-projecting the motion maps from the base image resolution level to the target image resolution level (page 11, line 32 - page 12, line 2; FIG. 2B, block 62).

K. Claim 18

Claim 18 depends from claim 1 and recites that regions of the target image are respectively assigned to a motion class selected from a motion class set including a high motion class and a low motion class, and motion vectors of regions assigned to the high motion class have higher magnitudes than motion vectors of regions assigned to the low motion class (page 10, lines 21-25).

L. Claim 20

Claim 20 depends from claim 19 and recites that pixel value contributions from the re-mapped neighboring images are additionally weighted based on measures of temporal distance between the reference image and the corresponding neighboring images (page 14, lines 3-5).

M. Claim 21

Claim 21 depends from claim 18 and recites that computing target image pixel values in regions assigned to the low motion class comprises classifying low motion class reference

image pixels and their corresponding pixels in the neighboring images based on measures of local texture richness (page 14, lines 29-31; FIG. 9, block 80).

N. Claim 22

Claim 22 depends from claim 21 and recites that low motion class reference image pixels and their corresponding pixels in the neighboring images are quantitatively evaluated for local texture richness (page 14, lines 12-14; FIG. 9, block 78), and are classified into a texture class selected from the texture class set including a high texture region class and a low texture region class (page 14, line 31 - page 15, line 3), and pixels assigned to the high texture region class have higher local texture measures than pixels assigned to the low texture region class (page 15, lines 1-3).

O. Claim 23

Claim 23 depends from claim 22 and recites that values of target image pixels classified into the low texture region class in the reference image and all of the respective neighboring images, are computed by interpolating up-projected pixel values of the reference image (page 15, lines 4-8; FIG. 9, blocks 82, 84).

P. Claim 24

Claim 24 depends from claim 22 and recites that a value of a given target image pixel classified into the high texture region class in the reference image or any respective neighboring images is computed based on a pixel value contribution from the up-projected reference image, and a pixel value contribution from a given re-mapped neighboring image weighted based on a measure of local texture richness computed for the given pixel, a measure of motion estimation accuracy computed for the given pixel , and a measure of temporal distance of the neighboring image from the reference image (page 15, lines 8-18; FIG. 9, blocks 82, 86).

Q. Claim 25

Claim 25 depends from claim 18 and recites that values of target image pixels are computed based on pixel value contributions from a number of base images neighboring the

reference image, the number of neighboring base images being different for different motion classes (page 13, lines 6-14).

R. Independent claim 28

The aspect of the invention defined in independent claim 28 is an image processing machine that comprises a computer-readable memory storing computer process instructions and a computer processor operable to execute the computer process instructions (see page 4, lines 8-16; page 15, line 25 - page 16, line 16). The computer processor computes a respective motion map for each pairing of a reference image and a respective image neighboring the reference image in a sequence of base images (page 5, lines 12-14; FIG. 2A, block 19). Each motion map comprises a set of motion vectors mapping reference image pixels to respective neighboring image pixels at sub-pixel accuracy (see page 5, lines 14-16). The computer processor assigns respective regions of a target image to motion classes based on the computed motion maps (see page 5, lines 16-17; FIG. 2A, block 21). The target image has a target resolution level and the base images having a base resolution level equal to or lower than the target resolution level (see page 5, lines 17-19). The computer processor computes pixel values for the target image based on corresponding pixel value contributions from the re-mapped base images selected in accordance with the motion classes assigned to the target image regions (see page 5, lines 19-22; FIG. 2A, block 23).

S. Independent claim 42

The aspect of the invention defined in independent claim 42 is a computer-readable medium storing computer-readable instructions operable to cause a computer to perform operations (see page 15, line 25 - page 16, line 16). The computer-readable instructions operable to cause a computer to compute a respective motion map for each pairing of a reference image and a respective image neighboring the reference image in a sequence of base images (see page 5, lines 12-14; FIG. 2A, block 19). Each motion map comprises a set of motion vectors mapping reference image pixels to respective neighboring image pixels at sub-pixel accuracy (see page 5, lines 14-16). The computer-readable instructions operable to cause the computer to assign respective regions of a target image to motion classes based on the computed motion maps (see page 5, lines 16-17; FIG. 2A, block 21). The target image has a target resolution level and the base images having a base resolution level equal to or

lower than the target resolution level (see page 5, lines 17-19). The computer-readable instructions operable to cause the computer to compute pixel values for the target image based on corresponding pixel value contributions from the re-mapped base images selected in accordance with the motion classes assigned to the target image regions (see page 5, lines 19-22; FIG. 2A, block 23).

VI. Grounds of Rejection to be Reviewed on Appeal

A. Claims 1-3, 11, 16, 17, 28, 29, 32, 37, 42, 43, 46, and 51 stand rejected under 35 U.S.C. § 103(a) over Schultz ("Subpixel Motion Estimation for Super-Resolution Image Sequence Enhancement") in view of Paniconi (U.S. 7,088,773).

B. Claims 4, 5, and 44 stand rejected under 35 U.S.C. § 103(a) over Schultz ("Subpixel Motion Estimation for Super-Resolution Image Sequence Enhancement") in view of Paniconi (U.S. 7,088,773) and Hanna (U.S. 6,269,175).

C. Claims 6, 12-15, 31, 33-36, 45, and 47-50 stand rejected under 35 U.S.C. § 103(a) over Schultz ("Subpixel Motion Estimation for Super-Resolution Image Sequence Enhancement") in view of Paniconi (U.S. 7,088,773) and Eren ("Robust, Object-Based High-Resolution Image Reconstruction from Low-Resolution Video").

D. Claims 7-10, 18-27, 38-41, and 52-55 stand rejected under 35 U.S.C. § 103(a) over Schultz ("Subpixel Motion Estimation for Super-Resolution Image Sequence Enhancement") in view of Paniconi (U.S. 7,088,773), Eren ("Robust, Object-Based High-Resolution Image Reconstruction from Low-Resolution Video"), and Kondo (U.S. 6,307,560).

VII. Argument

A. Applicable standards for sustaining a rejection under 35 U.S.C. § 103(a)

"A patent may not be obtained ... if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." 35 U.S.C. §103(a).

In an appeal involving a rejection under 35 U.S.C. § 103, an examiner bears the initial burden of establishing *prima facie* obviousness. See In re Rijckaert, 9 F.3d 1531, 1532, 28

USPQ2d 1955, 1956 (Fed. Cir. 1993). To support a *prima facie* conclusion of obviousness, the prior art must disclose or suggest all the limitations of the claimed invention.[1] See In re Lowry, 32 F.3d 1579, 1582, 32 USPQ2d 1 031, 1034 (Fed. Cir. 1994). If the examiner has established a *prima facie* case of obviousness, the burden of going forward then shifts to the applicant to overcome the *prima facie* case with argument and/or evidence. Obviousness, is then determined on the basis of the evidence as a whole and the relative persuasiveness of the arguments. This inquiry requires (a) determining the scope and contents of the prior art; (b) ascertaining the differences between the prior art and the claims in issue; (c) resolving the level of ordinary skill in the pertinent art; and (d) evaluating evidence of secondary consideration. See KSR Int'l Co. v. Teleflex Inc., No. 127 S. Ct. 1727, 1728 (2007) (citing Graham v. John Deere, 383 U.S. I, 17-18, 148 USPQ 459, 467 (1966)). If all claim limitations are found in a number of prior art references, the fact finder must determine whether there was an apparent reason to combine the known elements in the fashion claimed. See KSR, 1741. This analysis should be made explicit. KSR at 1741 (citing In re Kahn, 441 F. 3d 977, 988 (Fed. Cir. 2006): "[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness").

[1] The U.S. Patent and Trademark Office has set forth the following definition of the requirements for establishing a *prima facie* case of unpatentability (37 CFR § 1.56(b)(ii):

> A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

B. Rejection of claims 1-3, 11, 16, 17, 28, 29, 32, 37, 42, 43, 46, and 51 under 35 U.S.C. § 103(a)

The Examiner has rejected claims 1-3, 11, 16, 17, 28, 29, 32, 37, 42, 43, 46, and 51 under 35 U.S.C. § 103(a) over Schultz ("Subpixel Motion Estimation for Super-Resolution Image Sequence Enhancement") in view of Paniconi (U.S. 7,088,773).

1. Independent claim 1

Independent claim 1 recites:

> 1. A machine-implemented image processing method, comprising:
>
> computing a respective motion map for each pairing of a reference image and a respective image neighboring the reference image in a sequence of base images, each motion map comprising a set of motion vectors mapping reference image pixels to respective neighboring image pixels;
>
> assigning respective regions of a target image to motion classes based on the computed motion maps, the target image having a target resolution level and the base images having a base resolution level equal to or lower than the target resolution level; and
>
> computing pixel values for the target image based on corresponding pixel value contributions from the base images selected in accordance with the motion classes assigned to the target image regions.

The rejection of claim 1 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi should be withdrawn because Schultz and Paniconi, taken either alone or in any permissible combination, do not disclose or suggest all the limitations of the claimed invention. The rejection of claim 1 also should be withdrawn because at the time the invention was made there was no apparent reason to combine the teachings of Schultz and Paniconi in the fashion claimed.

2. The Examiner's position

The rejection of independent claim 1 is premised on the following assertions regarding the teachings of Schultz:

1. Schultz discloses the "computing a respective motion map" element of claim 1 on page 38 (see page 2, last full ¶ of the final Office action);

2. Schultz discloses the "assigning" element of claim 1 in the abstract and sections 2-3 (see page 2, second from last line - page 3, end of first full ¶ of the final Office action); and

3. Schultz discloses the "computing pixel values" element of claim 1 in sections 2 and 3 (see page 3, second full ¶ of the final Office action).

The Examiner's assertions regarding Schultz' disclosure of the "assigning" and "computing" elements of claim 1 are premised on the Examiner's assertion that each motion vector disclosed on Schultz constitutes a respective motion class that is assigned to a respective region (see, e.g., page 3, last three lines of the final Office action). As explained in detail below, this premise improperly conflates the "motion classes" elements of claim 1 with the "motion vectors" elements of claim 1 and, thereby, effectively reads the "motion classes" elements out of the claim.

The Examiner has relied on the following teachings of Paniconi in an effort to make-up for the failure of Schultz to "explicitly use the phrase 'motion classes'" (see page 4, line 1 through end of first full ¶ of the final Office action; emphasis added):

> However, performing motion estimation using motion classes is well known in the art, as taught by Paniconi, who discloses <u>assigning respective regions of a target image to motion classes based on the computed motion maps</u> (figure 2 block 202 computes a motion map and block 204 assigns regions to motion classes) and <u>computing pixel values for the target image based on corresponding pixel value contributions from the base images selected in accordance with the motion classes assigned to the target image regions</u> (column 2 lines 3949, methods for motion segmentation can divide a frame into a number of motion classes, where each moving object is assigned to its own motion class. See also figure 2). The purpose of performing motion estimation with motion classes is to compute pixel values for the target image based on corresponding pixel values (or "pixel value contributions") from other (or "base") images selected in accordance with the motion classes assigned to the target image regions, as taught by Paniconi in col. 1 lines 28-42.

3. Appellant's rebuttal: Schultz in view of Paniconi does not disclose each and every element of the invention defined in claim 1

a. Neither Schultz nor Paniconi discloses or suggests the "assigning" element of claim 1

i. Schultz does not disclose or suggest the "assigning" element of claim 1

Contrary to the Examiner's position, Schultz does not disclose the "assigning" element of claim 1 in the abstract and in sections 2-3 (see page 2, second from last line - page 3, end of first full ¶ of the final Office action).

Schultz' abstract does not disclose or suggest "assigning respective regions of a target image to motion classes based on the computed motion maps, the target image having a target resolution level and the base images having a base resolution level equal to or lower than the target resolution level," as recited in claim 1. Instead, the abstract discloses that super-resolution enhancement algorithms are used to estimate a high-resolution video still (HRVS) from several low-resolution frames. In particular, the abstract discloses that Bayesian multiframe enhancement algorithms that incorporate subpixel motion vectors are used to compute an HRVS from spatial information in each frame and temporal information due to object motion between frames. The abstract does not disclose or suggest anything whatsoever about "assigning respective regions of a target image to motion classes based on the computed motion maps."

In section 2, Schultz does not disclose or suggest "assigning respective regions of a target image to motion classes based on the computed motion maps, the target image having a target resolution level and the base images having a base resolution level equal to or lower than the target resolution level," as recited in claim 1. Instead, section 2 describes a motion-compensated subsampling model (see § 2.1) and the derivation of a Bayesian multiframe resolution enhancement algorithm from the subsampling model (see § 2.2). The motion-compensated subsampling model maps qxq high-resolution pixels into a low-resolution pixel (see, e.g., equation 2, equation 6, and the related description on pages 39-40). The Bayesian multiframe enhancement algorithm uses a maximum a posteriori (MAP) estimation technique to compute the HRVS from low-resolution frames. The MAP estimation technique incorporates a discontinuity-preserving Huber edge penalty function before integrating progressively scanned video frames (see equation 14 and related description). Neither the

subsampling model nor the resulting Bayesian enhancement algorithm even remotely involves "assigning respective regions of a target image to motion classes based on the computed motion maps."

In section 3, Schultz does not disclose or suggest "assigning respective regions of a target image to motion classes based on the computed motion maps, the target image having a target resolution level and the base images having a base resolution level equal to or lower than the target resolution level," as recited in claim 1. Instead, section 3 discloses several motion estimation techniques each of which involves up-sampling two successive low-resolution video frames and estimating subpixel-resolution motion vectors from the up-sampled frames (see section 3, first paragraph). The estimated subpixel-resolution motion vectors are down-sampled to obtain a single subpixel-resolution motion vector estimate for each pixel in the image sequence (see section 3, first paragraph). Inaccurate motion estimates are detected and eliminated (see section 3.4). None of the subpixel motion estimation techniques disclosed in section 3 even remotely involves "assigning respective regions of a target image to motion classes based on the computed motion maps."

The Examiner has taken the position that "section 3.2 describes a block matching motion estimation process that creates a motion map for objects that move independently in image sequences, and assigns respective regions of the target image to motion vectors based on the computed motion maps by determining separate motion fields (or "motion classes") for compact blocks (or "respective regions") in the image sequences" (see page 3, first full ¶ of the final Office action). The Examiner, however, has misconstrued Schultz' disclosure. In particular, section 3.2 does not disclose that block matching motion estimation involves (i) computing a motion map and (ii) assigning respective regions of an image to motion vectors based on the computed motion maps, as asserted by the Examiner. Instead, as is well-known in the art, block matching motion estimation involves estimating a single motion vector that maps the pixels of a block of a first image to a matching block of a second image (see, e.g., § 3.2, second ¶). That is, the block matching motion estimation process described in section 3.2 only involves determining a motion map that contains motion vectors between matching blocks of a pair of images; it does not involve a separate step of assigning motion vectors to regions -- indeed, the motion map already contains a motion vector for each block.

The Examiner also has misconstrued the terms "motion vector" and "motion field", as used in Schultz. In particular, the Examiner has taken the position that "each motion vector

represents a motion class assigned to a respective region" and that "each motion field of a compact block is a motion class assigned to a respective region" (see page 3, last three lines through page 4, line 2). In accordance with Schultz' disclosure, motion vectors and motion fields are not motion classes nor are they assigned to respective region of an image "based on the computed motion maps." Instead, a "motion vector" is an estimate of the motion between pixels of the pair of images and a "motion field" is a collection of the motion vectors estimated for a pair of images.

The Examiner's position that Schultz discloses the "assigning" element of claim 1 amounts to no more than an improper conflation of the "motion classes" elements of claim 1 with the "motion vectors" elements of claim 1. In particular, the Examiner's position relies on a single element of Schultz' disclosure (i.e., the motion vectors of a motion map) to meet two separate and discrete elements recited in claim 1 (i.e., the "motion vectors" and the "motion classes"). In effect, the Examiner's rejection of claim 1 impermissibly relies on reading the "motion classes" element out of the claim.

For at least the reasons explained above, Schultz does not disclose or suggest the "assigning" element of claim 1.

<u>ii. Paniconi does not disclose or suggest the "assigning" element of claim 1</u>

Contrary to the Examiner's position, Paniconi does not disclose "assigning respective regions of a target image to motion classes based on the computed motion maps" in FIG. 2 (see page 4, line 1 through end of first full ¶ of the final Office action).

In FIG. 2 and the accompanying description in the specification, Paniconi discloses a motion segmentation process (see col. 3, lines 24-25). In this process, a motion vector is determined for each block of a frame (see col. 3, lines 31-53; FIG. 2, block 202). The motion vectors then are clustered (see col. 3, lines 55-58) and each cluster of motion vectors is assigned to a respective object class (see col. 3, lines 58-59). The assignment of motion vector clusters to an object class does not constitute "assigning respective regions of a target image to <u>motion classes</u>," as recited in claim 1. Indeed, object classes define groups of motion vectors sharing common attributes representing different objects (see Paniconi, col. 3, lines 59-61" "Each object can define a class"), whereas motion classes define groups of motion vectors sharing common attributes representing different motions (see, e.g., page 11, lines 13-31; also see page 10, lines 20-32: "e.g., a high motion class region 58, intermediate

motion class regions 54, 56, and a low motion class region 52").[2] Although clustering techniques (e.g., k-means clustering) may be involved in the processes of segmenting motion vectors into different objects and segmenting motion vectors into different motions, the process of segmenting motion vectors into different motions additionally involves grouping motion vectors in accordance with a motion taxonomy; the process of segmenting motion vectors into different objects does not involve the use of such a taxonomy.

For at least the reasons explained above, Paniconi does not disclose or suggest the "assigning" element of claim 1.

iii. Summary regarding the "assigning" element of claim 1

For at least the reasons explained above, neither Schultz nor Paniconi discloses or suggests the "assigning" element of claim 1. Therefore, the rejection of claim 1 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi should be withdrawn.

b. Neither Schultz nor Paniconi discloses the "computing pixel values" element of claim 1

i. Schultz does not disclose or suggest the "computing pixel values" element of claim 1

As explained above, Schultz does not disclose "assigning respective regions of a target image to motion classes." Therefore, Schultz cannot possibly disclose "computing pixel values for the target image based on corresponding pixel value contributions from the base images selected in accordance with the motion classes assigned to the target image regions," as recited in claim 1.

The Examiner has taken the position that Schultz discloses the "computing pixel values" element of claim 1 in sections 2-3. In particular, the Examiner has taken the position that "... the super resolution images that are created by Schultz's method are created by pixel value contributions from other images selected in accordance with the motion estimates assigned to the target image regions as discussed at length by Schultz throughout sections 2 and 3" (see page 3, last full ¶). As explained above, however, the motion estimates disclosed in Schultz do not constitute motion classes. Moreover, the Examiner's position in this regard

[2] The pertinent definition of "class" is "a group, set, or kind sharing common attributes" (Merriam-Webster's Collegiate Dictionary, Tenth Edition (1995).

improperly conflates the "motion classes" elements of claim 1 with the "motion vectors" elements of claim 1 and, thereby, effectively reads the "motion classes" elements out of the claim.

For at least the reasons explained above, Schultz does not disclose or suggest the "computing pixel values" element of claim 1.

ii. Paniconi does not disclose or suggest the "computing pixel values" element of claim 1

Contrary to the Examiner's position, Paniconi does not disclose "computing pixel values for the target image based on corresponding pixel value contributions from the base images selected in accordance with the motion classes assigned to the target image regions" in col. 2, lines 39-49 and in FIG. 2 (see page 4, line 1 through end of first full ¶ of the final Office action).

In col. 2, lines 39-49, Paniconi teaches:

> FIG. 1a illustrates a frame having objects according to one embodiment. Methods for motion segmentation can divide a frame containing an image in a video sequence into a number of classes. For example, frame 102 has three moving objects, object 104, object 106, and object 108. An encoder could assign the region defining each moving object 104, 106, and 108 to its own class. The class can then be tracked from frame to frame using vectors rather than encoding the entire object in each frame. In this way, a great deal of processing and data storage can be saved because the object need only be encoded.

Contrary to the Examiner's position, however, the mere teaching that "methods for motion segmentation can divide a frame into a number of motion classes, where each moving object is assigned to its own motion class" does not constitute a teaching of "computing pixel values for the target image based on corresponding pixel value contributions from the base images selected in accordance with the motion classes assigned to the target image regions." The cited teaching does not disclose or suggest anything whatsoever about a target image with pixel values computed based on corresponding pixel value contributions from base images in a sequence, much less anything whatsoever about such a target image in which the pixel value contributions from the base images are selected in accordance with the motion classes

assigned to the target image regions. Instead, the cited disclosure simply discloses that each of the object classes can be tracked from frame to frame.

iii. Summary regarding the "computing pixel values" element of claim 1

For at least the reasons explained above, neither Schultz nor Paniconi discloses or suggests the "computing pixel values" element of claim 1. Therefore, the rejection of claim 1 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi should be withdrawn.

iv. Conclusion

For the reasons explained above, Schultz in view of Paniconi do not disclose the "assigning" and "computing pixel values" elements of claim 1. Accordingly, the rejection of claim 1 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi should be withdrawn because the cited references do not disclose or suggest all of the elements of the claim.

c. Appellant's rebuttal: one skilled in the art at the time the invention was made would not have had any apparent reason to modify the teachings of Schultz in the manner proposed by the Examiner

The rejection of claim 1 under 35 U.S.C. § 103(a) over Schultz and Paniconi also should be withdrawn because at the time the invention was made there was no apparent reason to combine the teachings of Schultz and Paniconi in the fashion claimed in claim 1.

Schultz discloses a method for determining a high-resolution video still image from low-resolution video frames. In accordance with this method, two successive low-resolution video frames are up-sampled to the high-resolution level and subpixel-resolution motion vectors are estimated from the up-sampled frames (see section 3, first paragraph). The estimated subpixel-resolution motion vectors are down-sampled to obtain a single subpixel-resolution motion vector estimate for each pixel in the low-resolution video frames (see section 3, first paragraph). Inaccurate motion estimates are detected and eliminated (see section 3.4). The remaining subpixel-resolution motion vectors are used to determine the pixel values of the high-resolution video still image (see section 2).

Paniconi discloses a motion segmentation method that involves determining motion vectors between low-resolution video frames (see col. 3, lines 31-53), classifying motion vectors of pixels in low-resolution video frames (see col. 3, line 54 - col. 4, line 21), and

enhancing the motion classification results (see col. 4, line 22 - col. 7, line 29). The final motion classification results are used by a video encoder to encode digital video (see col. 1, line 60 - col. 2, line 11).

The Examiner has asserted that "It would have been obvious to one of ordinary skill in the art to include the motion classes of Paniconi with the super resolution enhancement algorithm of Schultz, because each class can be tracked across frames using vectors, which saves processing time as taught by Paniconi." Contrary to the Examiner's statement, however, one skilled in the art would have had any apparent reason to "include the motion classes of Paniconi with the super resolution enhancement algorithm of Schultz" because neither Schultz nor Paniconi discloses or suggests how such a modification of Schultz' teachings would have served any useful purpose whatsoever. For example, although it is possible to classify the low-resolution video frames disclosed in Schultz using the motion classification process disclosed in Schultz, neither Schultz nor Paniconi discloses or suggests how the results of such motion classification would serve any useful purpose in the context of Schultz' super-resolution image enhancement process. Moreover, neither Schultz nor Paniconi even hints that such motion classification results might be used in determining the pixel values of the high-resolution video still image.

Instead of pointing to some teaching or suggestion in Schultz, Paniconi, or the knowledge generally available to support the proposed combination of Schultz and Paniconi, the Examiner has relied on circular reasoning. In particular, the Examiner's proffered motivation (i.e., "because each motion class can be tracked across frames using vectors, which saves processing time as taught by Paniconi col. 2 lines 45-49"; see page 5, lines 5-7 of the final Office action) assumes the result (i.e., the modification of Schultz' system) to which the proffered "motivation" was supposed to have led one skilled in the art. Such circular reasoning cannot possibly support a rejection under 35 U.S.C. § 103(a). Indeed, such circular reasoning only evidences the fact that the Examiner improperly has engaged in impermissible hindsight reconstruction of the claimed invention, using applicants' disclosure as a blueprint for piecing together elements from the prior art in a manner that attempts to reconstruct the invention recited in claim 1 only with the benefit of impermissible hindsight (see KSR Int'l Co. v. Teleflex Inc., slip op. at 17: "A factfinder should be aware, of course, of the distortion caused by hindsight bias and must be cautious of arguments reliant upon ex post reasoning."). The fact is that neither Schultz nor Paniconi nor the knowledge generally

available at the time the invention was made would have led one skilled in the art to believe that there was any problem to be solved or any advantage that would be gained by the Examiner's proposed modification of Schultz's system.

Without any apparent reason for modifying Schultz' disclosure, the Examiner's rationale in support of the rejection of claim 1 amounts to no more than a conclusory statement which cannot support a rejection under 35 U.S.C. § 103. See KSR at 1741 (citing In re Kahn, 441 F. 3d 977, 988 (Fed. Cir. 2006): "[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness").

For at least this additional reason, the rejection of claim 1 under 35 U.S.C. § 103(a) over Schultz and Paniconi should be withdrawn.

2. Claims 2, 3, 11, 16, and 17

a. Introduction

Each of claims 2, 3, 11, 16, and 17 incorporates the elements of independent claim 1 and therefore is patentable over Schultz in view of Paniconi for at least the same reasons explained above.

Claims 3, 11, and 16 also are patentable over Schultz in view of Paniconi for the following additional reasons.

b. Claim 3

Claim 3 depends from claim 1 and recites that assigning regions of the target image to motion classes comprises assigning pixels of the reference image to respective motion classes and up-projecting the motion class assignments to pixels of the target image.

In support of the rejection of claim 3, the Examiner has taken the position that "...Paniconi discloses assigning pixels of the reference image to respective motion classes and up-projecting the motion class assignments to pixels of the target image (see for example figures 1a, 1band 1c which show classes projected to pixels, see also column 6 lines 1-24)" (see page 6, second full ¶ of the final Office action).

Contrary to the Examiner's position, however, the cited disclosure does not show up-projecting the motion class assignments to pixels of a target image, where the pixel values of

the target image are computed based on corresponding pixel value contributions from the base images (see the "computing pixel values" element of claim 1). Instead, FIGS. 1a-1c show the positions of moving objects in successive original frames of a video sequence; none of these frames has pixel values that are computed based on corresponding pixel value contributions. In col. 6, lines 1-24, Paniconi discloses that referencing more frames before or after a current frame will increase the accuracy of the object classification. This disclosure does not teach or suggest anything whatsoever about up-projecting motion class assignments to pixels of a target image as defined in claim 3.

For at least this additional reason, the rejection of claim 3 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi should be withdrawn.

c. Claim 11

Claim 11 depends from claim 1 and recites "computing an alignment accuracy map for each pairing of the reference image and a respective neighboring image based on the computed motion maps."

In support of the rejection of claim 11, the Examiner has taken the position that "...Schultz discloses computing an alignment accuracy map for each pairing of the reference image and a respective neighboring image based on the computed motion maps (page 43, the displaced frame difference along with its mean and variance are computed to determine how well the motion vectors have been estimated)" (see page 6, last ¶ of the final Office action).

Contrary to the Examiner's position, however, the cited disclosure does not disclose or suggest "computing an alignment accuracy map for each pairing of the reference image and a respective neighboring image." Instead, the displaced frame difference is computed "between the up-sampled frame t and the compensated image from frame k" (see § 3.4, second ¶). The up-sampled frame does not constitute the reference image as defined in claim 11 (for example, the up-sampled image does not neighbor an image in a sequence of base images). Therefore, the displaced frame difference along with its mean and variance do not constitute an alignment accuracy map for a pairing of the reference image and a respective neighboring image.

For at least this additional reason, the rejection of claim 11 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi should be withdrawn.

d. Claim 16

Claim 16 depend from claim 1 and recites up-projecting the motion maps from the base image resolution level to the target image resolution level.

In support of the rejection of claim 16, the Examiner has taken the position that "...Schultz discloses up-projecting the motion maps from the base image resolution level to the target image resolution level (see page 45, the up-sampled frames produce the up-sampled subpixel resolution motion vectors)" (see page 7, first ¶ of the final Office action).

Contrary to the Examiner's position, however, the cited disclosure does not disclose or suggest "up-projecting the motion maps from the base image resolution level to the target image resolution level." Instead, the cited disclosure teaches that the low-resolution image frames themselves are upsampled and the motion vectors are determined from the up-sampled image frames (see page 45, numbered ¶¶ 1 and 2).

For at least this additional reason, the rejection of claim 16 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi should be withdrawn.

3. Claims 28, 29, 32, 37

Independent claim 28 recites elements that essentially track the pertinent elements of independent claim 1 discussed above. Therefore claim 28 is patentable over Schultz in view of Paniconi for at least the same reasons explained above.

Each of claims 29, 32, and 37 incorporates the elements of independent claim 28 and therefore is patentable over Schultz in view of Paniconi for at least the same reasons.

Claims 29 and 32 also are patentable over Schultz in view of Paniconi for the same additional reasons explained above in connection with claims 3 and 11.

4. Claims 42, 43, 46, and 51

Independent claim 42 recites elements that essentially track the pertinent elements of independent claim 1 discussed above. Therefore claim 42 is patentable over Schultz in view of Paniconi for at least the same reasons explained above.

Each of claims 43, 46, and 51 incorporates the elements of independent claim 42 and therefore is patentable over Schultz in view of Paniconi for at least the same reasons.

Claims 43 and 46 also are patentable over Schultz in view of Paniconi for the same additional reasons explained above in connection with claims 3 and 11.

C. Rejection of claims 4, 5, and 44 under 35 U.S.C. § 103(a)

The Examiner has rejected claims 4, 5, and 44 under 35 U.S.C. § 103(a) over Schultz ("Subpixel Motion Estimation for Super-Resolution Image Sequence Enhancement") in view of Paniconi (U.S. 7,088,773) and Hanna (U.S. 6,269,175).

Each of claims 4 and 5 incorporates the elements of independent claim 1; claim 5 incorporates the elements of independent claim 28; claim 44 incorporates the elements of independent claim 42. Hanna does not make-up for the failure of Schultz and Paniconi to disclose or suggest all the elements of any of the independent claims 1, 28, and 42. Therefore, claims 4, 5, 30, and 44 are patentable over Schultz, Paniconi, and Hanna for at least the same reasons explained above.

Each of claims 4, 5, 30, and 44 also are patentable over Schultz in view of Paniconi and Hanna for the following additional reasons.

Claim 4 depends from claim 3 and recites that assigning reference image pixels to motion classes comprises <u>computing motion magnitude maps from each motion map</u>, down-sampling the computed motion magnitude maps to a pyramid of motion magnitude maps at respective resolution levels lower than the base resolution level, and segmenting pixels in the pyramid of down-sampled motion magnitude maps into motion classes.

The rejection of claim 4 is premised on the Examiner's assertion that "Paniconi discloses computing motion magnitude maps from each motion map (see columns 8-9 and figures 6a, 6b, 6c, 6d, 6e and 6f, although Paniconi does not use the words 'motion magnitude maps,' he clearly computes the motion magnitude map for each class from the motion map as shown for example in the discussion of figure 6c)" (see page 7, last ¶ of the final Office action).

Contrary to the Examiner's assertion, however, Paniconi does not disclose or suggest "computing motion magnitude maps from each motion map," as recited in claim 4. Instead, Paniconi only discloses computing a motion map of motion vectors (see, e.g., col. 3, lines 31-48, where Paniconi discloses that the motion vectors are computed by determining the values of the motion model parameters a, b, c, d, e, f. Paniconi does not even hint that the magnitudes of the motion vectors are computed. In addition, one skilled in the art would not

have had any apparent reason to compute motion magnitude maps from the motion vectors because such magnitudes would not serve any apparent useful purpose in the context of Paniconi's method. Indeed, a map of motion vector magnitudes would not advance Paniconi's objective of segmenting objects in the images.

For at least this additional reason, the rejection of claim 4 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi and Hanna should be withdrawn.

Claim 5 depends from claim 4 and therefore is patentable over Schultz in view of Paniconi and Hanna for the same additional reasons explained above in connection with claim 4.

Each of claims 30 and 44 recites elements that essentially track the pertinent elements of claim 4 and therefore is patentable over Schultz in view of Paniconi and Hanna for the same additional reasons explained above in connection with claim 4.

D. Rejection of claims 6, 12-15, 31, 33-36, 45, and 47-50 under 35 U.S.C. § 103(a)

1. Introduction

The Examiner has rejected claims 6, 12-15, 31, 33-36, 45, and 47-50 under 35 U.S.C. § 103(a) over Schultz ("Subpixel Motion Estimation for Super-Resolution Image Sequence Enhancement") in view of Paniconi (U.S. 7,088,773) and Eren ("Robust, Object-Based High-Resolution Image Reconstruction from Low-Resolution Video").

Each of claims 6 and 12-15 incorporates the elements of independent claim 1; each of claims 31 and 33-36 incorporates the elements of independent claim 28; each of claims 45 and 47-50 incorporates the elements of independent claim 42. Eren does not make-up for the failure of Schultz and Paniconi to disclose or suggest all the elements of any of the independent claims 1, 28, and 42. Therefore, claims 6, 12-15, 31, 33-36, 45, and 47-50 are patentable over Schultz, Paniconi, and Eren for at least the same reasons explained above.

Each of claims 6 and 13-15 also is patentable over Schultz in view of Paniconi and Eren for the following additional reasons.

2. Claim 6

Claim 6 depends from claim 3 and recites assigning reference image pixels to motion classes comprises generating a separate motion class segmentation map for each pairing of

the reference image and a respective neighboring image and merging the separate motion class segmentation maps into a unified motion class segmentation map for the reference image.

In support of the rejection of claim 3, the Examiner has taken the position that (see page 8, last four lines through page 9, line 3; emphasis added):

> For claims 6, 31 and 45, Eren discloses generating a separate motion class segmentation map for each pairing of the reference image and a respective neighboring image and merging the separate motion class segmentation maps into a unified motion class segmentation map for the reference image (see pages 1448-49 and figures 1(a) and (e), the segmentation maps of each frame are given or can be computed, and the segmentation map of a reference frame is given. <u>The maps are used to create a high resolution mosaic</u>).

Contrary to the Examiner's position, however, the process of reconstructing partially covered pixels to produce a high-resolution object mosaic (see page 1449, § B) does not involve in any way "merging the separate motion class segmentation maps into a unified motion class segmentation map for the reference image." Instead, this process involves reconstructing covered pixels in the reference frame by projections of their uncovered observations in other frames based on different motion models for the background and foreground objects. In addition, the "single parametric motion model" mentioned in the first paragraph of § B on page 1449 does not constitute a unified motion class segmentation map as defined in claim 6; instead, the parametric motion model is the model used to estimate the motion vector field describing the motion of a moving object (see, e.g., page 1446, § 1, second paragraph).

For at least this additional reason, the rejection of claim 6 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi and Eren should be withdrawn.

<u>3. Claims 13-15</u>

Claim 13 depends from claim 11 and recites up-projecting the computed alignment accuracy maps from the base image resolution level to the target image resolution level.

In support of the rejection of claim 13, the Examiner has asserted that "... Eren discloses up-projecting the computed alignment accuracy maps from the base image

resolution level to the target image resolution level as discussed in section III" (see page 10, first ¶ of the final Office action).

Contrary to the Examiner's assertion, however, section III of Eren does not disclose "up-projecting the computed alignment accuracy maps from the base image resolution level to the target image resolution level." Instead, in section III Eren discloses that the validity map is computed between the motion compensated reference image and other low-resolution images (see § III, second ¶, last sentence) and that the projections are performed only for those pixel locations for which the motion vectors are accurate (see § III, first ¶, second to last sentence). That is, in accordance with Eren's disclosure, the high-resolution reconstruction is performed using the validity map computed at the resolution level of the low-resolution images, not an up-projected version of such a validity map as asserted by the Examiner.

For at least this additional reason, the rejection of claim 13 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi and Eren should be withdrawn.

Each of claims 14 and 15 incorporates the elements of claim 13 and therefore is patentable over Schultz in view of Paniconi and Eren for at least the same reasons.

E. Rejection of claims 7-10, 18-27, 38-41, and 52-55 under 35 U.S.C. § 103(a)

1. Introduction

The Examiner has rejected claims 7-10, 18-27, 38-41, and 52-55 under 35 U.S.C. § 103(a) over Schultz ("Subpixel Motion Estimation for Super-Resolution Image Sequence Enhancement") in view of Paniconi (U.S. 7,088,773), Eren ("Robust, Object-Based High-Resolution Image Reconstruction from Low-Resolution Video"), and Kondo (U.S. 6,307,560).

Each of claims 7-10 and 18-27 incorporates the elements of independent claim 1; each of claims 38-41 incorporates the elements of independent claim 28; each of claims 52-55 incorporates the elements of independent claim 42. Neither Eren nor Kondo makes-up for the failure of Schultz and Paniconi to disclose or suggest all the elements of any of the independent claims 1, 28, and 42. Therefore, claims7-10, 18-27, 38-41, and 52-55 are patentable over Schultz, Paniconi, Eren, and Kondo for at least the same reasons explained above.

Each of claims 7-10, 18-27, 38-41, and 52-55 is patentable over Schultz, Paniconi, Eren, and Kondo for the following additional reasons.

2. Claim 7

Claim 7 depends from claim 6 and recites that reference image pixels are respectively assigned to a motion class selected from a motion class set including a high motion class and a low motion class, and motion vectors assigned to the high motion class have higher magnitudes than motion vectors assigned to the low motion class.

In support of the rejection of claim 7, the Examiner has taken the position that (see page 11, lines 3-6 of the final Office action):

> It would have been obvious to one of ordinary skill in the art at the time of invention to include the low and high motion classes of Kondo with the motion classes' of Paniconi for the benefit of varying the description of the motion according to the application as taught by Kondo in column 5 line 25.

Contrary to the Examiner's assertion, one skilled in the art at the time the invention was made would not have had any apparent reason to modify Paniconi's method to include the motion classification method disclosed in Kondo. In particular, Paniconi method relies on assigning each motion vector cluster to a respective object class for the purpose of tracking objects. In accordance with Kondo's disclosure, input data from more than one instance of time are classified into motion classes for the purpose of determining filter weights that transform the input data into output data (e.g., to convert from one video format to another as described in col. 2, lines 22-25). Since Paniconi's method does not involve spatiotemporal format conversion of input data, one skilled in the art would not have had any reason to believe that the motion classification process described in Kondo would have served any useful purpose in Paniconi's object tracking method. Indeed, motion classes indicating no motion and a high level of motion as proposed in Kondo would not any apparent useful purpose in the context of object tracking because such classes are irrelevant for the task of tracking objects in a sequence of images. For example, in the case where two different objects are moving with the same magnitude, direction, or speed, Kondo's proposed motion classification would not distinguish the two objects.

In addition, the motivation given by the Examiner in support of the proposed modification of Paniconi's method (i.e., "for the benefit of varying the description of the motion according to the application as taught by Kondo in column 5 line 25"; see page 11, lines 5-6 of the final Office action) would not have led on skilled in the art to modify Panicon's method in the manner proposed by the Examiner. In particular, in col. 5, lines 24-25, Kondo discloses that the "number of class identifications (class ID) used to describe the input data can vary according to application." The number of classes that are used in Paniconi's "application" is set by the number of objects that are identified in the image frames (see, e.g., col. 2, lines 44-45). Therefore, one skilled in the art would not have had any reason whatsoever to change the number of class identifications "for the benefit of varying the description of the motion according to the application," as proposed by the Examiner. Indeed, as explained in the preceding paragraph, no benefit would result from the incorporation of Kondo's method into Panaconi's object tracking process.

Without any apparent reason for modifying Panaconi's disclosure, the Examiner's rationale in support of the rejection of claim 7 amounts to no more than a conclusory statement which cannot support a rejection under 35 U.S.C. § 103. See KSR at 1741 (citing In re Kahn, 441 F. 3d 977, 988 (Fed. Cir. 2006): "[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness").

For at least this additional reason, the rejection of claim 7 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi, Eren, and Kondo should be withdrawn.

3. Claim 8

Claim 8 depends from claim 7 and recites that merging the separate motion class segmentation maps comprises assigning a given reference image pixel to the low motion class in the unified motion class segmentation map when the given pixel is assigned to the low motion class in all of the separate motion class segmentation maps, and assigning a given reference image pixel to the high motion class in the unified motion class segmentation map when the given pixel is assigned to the high motion class in any of the separate motion class segmentation maps.

The Examiner has taken the position that Paniconi discloses each and every element of claim 8 in "figures 1a, 1b and 1c each object has its own class that is tracked over multiple

frames" (see page 11, second full ¶ of the final Office action). Contrary to the Examiner's position, however, FIGS. 1a-1c do not show any of the elements of claim 8. Instead, these figures only show the positions of moving objects in successive original frames of a video sequence.

For at least this additional reason, the rejection of claim 8 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi, Eren, and Kondo should be withdrawn.

4. Claim 9

Claim 9 depends from claim 8 and therefore is patentable over Schultz in view of Paniconi, Eren, and Kondo for at least the same additional reasons explained above in connection with claim 8.

5. Claim 10

Claim 10 depends from claim 9 and recites that merging the separate motion class segmentation maps comprises assigning a given reference image pixel to the intermediate motion class in the unified motion class segmentation map when the given pixel is unassigned to the high motion class in any of the separate motion class segmentation maps and is unassigned to the low motion class in all of the separate motion class segmentation maps.

The only explanation given by the Examiner in support of the rejection of claim 10 is as follows: "...Kondo discloses assigning a given reference image pixel to the intermediate motion class (column 5) and Paniconi and Eren disclose the unified motion class segmentation map" (see page 12, first ¶ of the final Office action). This explanation does not show that Schultz in view of Paniconi, Eren, and Kondo discloses or suggests that "a given reference image pixel to the intermediate motion class in the unified motion class segmentation map when the given pixel is unassigned to the high motion class in any of the separate motion class segmentation maps and is unassigned to the low motion class in all of the separate motion class segmentation maps." Thus, the Examiner has not shown that the cited references disclose all of the elements of claim 10 and therefore has not established a *prima facie* case of obviousness.

For at least this additional reason, the rejection of claim 10 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi, Eren, and Kondo should be withdrawn.

6. Claim 18

Claim 18 depends from claim 1 and recites that regions of the target image are respectively assigned to a motion class selected from a motion class set including a high motion class and a low motion class, and motion vectors of regions assigned to the high motion class have higher magnitudes than motion vectors of regions assigned to the low motion class.

Claim 18 is patentable over Schultz in view of Paniconi, Eren, and Kondo for at least the same reasons explained above in connection with claim 7. In particular, one skilled in the art at the time the invention was made would not have had any apparent reason to modify Paniconi's method to include the motion classification method disclosed in Kondo as relied upon by the Examiner in the rejection of claim 18.

7. Claim 19

Claim 19 depends from claim 18 and therefore is patentable over Schultz in view of Paniconi, Eren, and Kondo for at least the same additional reasons explained above in connection with claim 18.

8. Claim 20

Claim 20 depends from claim 19 and recites that pixel value contributions from the re-mapped neighboring images are additionally weighted based on measures of temporal distance between the reference image and the corresponding neighboring images.

In support of the rejection of claim 20, the Examiner has taken the position that Eren suggests each and every one of the elements of claim 20 because "the temporal distance is accounted for using motion vectors and the segmentation maps" (see page 12, last ¶ of the final Office action). Contrary to the examiner's position, however, motion vectors and segmentation maps do not constitute "measures of temporal distance". Moreover, there is nothing in Eren (or in any of the other cited references for that matter) that would have led one skilled in the art to weight the pixel value contributions from the re-mapped neighboring images based on measures of temporal distance between the reference image and the corresponding neighboring images, as recited in claim 20.

For at least this additional reason, the rejection of claim 20 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi, Eren, and Kondo should be withdrawn.

9. Claim 21

Claim 21 depends from claim 18 and recites that computing target image pixel values in regions assigned to the low motion class comprises classifying low motion class reference image pixels and their corresponding pixels in the neighboring images based on measures of local texture richness.

The Examiner has taken the position that Eren suggests each and every one of the elements of claim 21 on page 1449 because "the background is low motion that is classified based on texture" (see page 13, first ¶ of the final Office action). Contrary to the Examiner's position, however, page 1449 does not disclose or suggest that the background is classified based on texture. Instead, page 1449 describes a process of reconstructing partially covered pixels. This process does not involve classifying the background based on texture.

For at least this additional reason, the rejection of claim 21 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi, Eren, and Kondo should be withdrawn.

10 Claim 22

Claim 22 depends from claim 21 and recites that low motion class reference image pixels and their corresponding pixels in the neighboring images are quantitatively evaluated for local texture richness, and are classified into a texture class selected from the texture class set including a high texture region class and a low texture region class, and pixels assigned to the high texture region class have higher local texture measures than pixels assigned to the low texture region class.

The Examiner has taken the position that page 1448 of Eren and the abstract of Paniconi suggest disclose that "the low motion classes can be segmented into low motion background and low motion object based on the textures" (see page 13, second ¶ of the final Office action).

Contrary to the Examiner's position, however, neither page 1448 of Eren nor the abstract of Paniconi discloses or suggests that the low motion classes can be segmented into low motion background and low motion object based on the textures. Instead, page 1448 of Eren describes an object motion estimation process that does not involve classifying low

motion classes based on textures. The abstract of Paniconi discloses that motion segmentation may operate by determining multiple classification hypotheses and by re-classifying poorly classified regions according to the multi-frame hypothesis tracking algorithm but the abstract does not even hint that low motion classes can be segmented into low motion background and low motion object based on the textures.

In addition, the Examiner has not even attempted to show that the cited references disclose or suggest that "pixels assigned to the high texture region class have higher local texture measures than pixels assigned to the low texture region class." Therefore, the rationale give by the Examiner does not establish a *prima facie* case of obviousness.

For at least these additional reasons, the rejection of claim 22 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi, Eren, and Kondo should be withdrawn.

11. Claim 23

Claim 23 depends from claim 22 and recites that values of target image pixels classified into the low texture region class in the reference image and all of the respective neighboring images, are computed by interpolating up-projected pixel values of the reference image.

The sole explanation given by the Examiner in support of the rejection of claim 23 is that Eren discloses each and every one of the elements of claim 23 because "the pixel values of the background are determined from the reference image" (see page 13, third ¶ of the final Office action). Eren, however, does not explicitly disclose or suggest that the pixel values of the background are determined from the reference image. The Examiner is asked to provide support for this assertion. It is possible that the Examiner's position is that Eren discloses that all of the pixel values of the reconstructed image (including the background pixels) "are determined" from the reference image. In this case, however, such disclosure does not teach or suggest that "values of target image pixels classified into the low texture region class in the reference image and all of the respective neighboring images, are computed by interpolating up-projected pixel values of the reference image."

For at least this additional reason, the rejection of claim 23 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi, Eren, and Kondo should be withdrawn.

12. Claim 24

Claim 24 depends from claim 22 and recites that a value of a given target image pixel classified into the high texture region class in the reference image or any respective neighboring images is computed based on a pixel value contribution from the up-projected reference image, and a pixel value contribution from a given re-mapped neighboring image weighted based on a measure of local texture richness computed for the given pixel, a measure of motion estimation accuracy computed for the given pixel , and a measure of temporal distance of the neighboring image from the reference image.

The sole explanation given by the Examiner in support of the rejection of claim 24 is that Eren and Paniconi disclose each and every one of the elements of claim 24 because "the pixel values of a moving object are determined from texture, motion, and temporal images" (see page 13, last two lines through page 14, line 7 of the final Office action). Neither Eren nor Paniconi supports the Examiner's assertion that these references disclose or suggest that "the pixel values of a moving object are determined from texture, motion, and temporal images." The Examiner is requested to point to the locations in Eren and Paniconi that support this assertion or withdrawn the rejection of claim 24.

For at least this additional reason, the rejection of claim 24 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi, Eren, and Kondo should be withdrawn.

13. Claim 25

Claim 25 depends from claim 18 and recites that values of target image pixels are computed based on pixel value contributions from a number of base images neighboring the reference image, the number of neighboring base images being different for different motion classes.

The Examiner has taken the position that Paniconi disclose that the number of neighboring base images being different for different motion classes because "if an object is moving faster than another object, it will usually be present in fewer base images before it moves out of the field of view" (see page 14, first full ¶ of the final Office action). Paniconi, however, does not disclose or suggest anything about computing values of target image pixels. Therefore, contrary to the Examiner's assumption, Paniconi does not disclose or suggest anything that would have led on skilled in the art to compute target image pixels

based on pixel value contributions from a number of base images neighboring the reference image, where the number of neighboring base images is different for different motion classes. In addition, the number of base images in which an object appears does not affect the number of base images that are used in Eren's method to compute the pixel values of the reconstructed image. Therefore, the contrived scenario in which a faster moving object is present in fewer base images does not change the operation of Eren's image reconstruction method.

For at least this additional reason, the rejection of claim 25 under 35 U.S.C. § 103(a) over Schultz in view of Paniconi, Eren, and Kondo should be withdrawn.

14. Claim 26

Claim 26 depends from claim 25 and therefore is patentable over Schultz in view of Paniconi, Eren, and Kondo for at least the same reasons explained above in connection with claim 25.

15. Claim 27

Claim 27 depends from claim 26 and therefore is patentable over Schultz in view of Paniconi, Eren, and Kondo for the same reasons explained above in connection with claim 26.

16. Claims 38-41

Claims 38-41 recite elements that essentially track the pertinent elements of claims 19-21 and 25, respectively, and therefore are patentable over Schultz in view of Paniconi, Eren, and Kondo for at least the same reasons explained above.

17. Claims 52-55

Claims 52-55 recite elements that essentially track the pertinent elements of claims 19-21 and 25, respectively, and therefore are patentable over Schultz in view of Paniconi, Eren, and Kondo for at least the same reasons explained above.

VIII. Conclusion

For the reasons explained above, all of the pending claims are now in condition for allowance and should be allowed.

Charge any excess fees or apply any credits to Deposit Account No. 08-2025.

Respectfully submitted,

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CLAIMS APPENDIX

The claims that are the subject of Appeal are presented below.

Claim 1 (original): A machine-implemented image processing method, comprising:

computing a respective motion map for each pairing of a reference image and a respective image neighboring the reference image in a sequence of base images, each motion map comprising a set of motion vectors mapping reference image pixels to respective neighboring image pixels;

assigning respective regions of a target image to motion classes based on the computed motion maps, the target image having a target resolution level and the base images having a base resolution level equal to or lower than the target resolution level; and

computing pixel values for the target image based on corresponding pixel value contributions from the base images selected in accordance with the motion classes assigned to the target image regions.

Claim 2 (original): The method of claim 1, wherein computing motion maps comprises generating for each image pair respective dense motion vectors describing motion at pixel locations with respective sets of parameters in a motion parameter space at sub-pixel accuracy.

Claim 3 (original): The method of claim 1, wherein assigning regions of the target image to motion classes comprises assigning pixels of the reference image to respective motion classes and up-projecting the motion class assignments to pixels of the target image.

Claim 4 (original): The method of claim 3, wherein assigning reference image pixels to motion classes comprises computing motion magnitude maps from each motion map, down-sampling the computed motion magnitude maps to a pyramid of motion magnitude maps at respective resolution levels lower than the base resolution level, and segmenting pixels in the pyramid of down-sampled motion magnitude maps into motion classes.

Claim 5 (original): The method of claim 4, wherein assigning reference image pixels to motion classes further comprises iteratively segmenting pixels in the pyramid of motion magnitude maps from a coarsest resolution level up to the base resolution level, wherein segmentation from each coarser resolution level is up-sampled to initialize the segmentation at a finer resolution level, and refined by further segmentation at the finer resolution level.

Claim 6 (original): The method of claim 3, wherein assigning reference image pixels to motion classes comprises generating a separate motion class segmentation map for each pairing of the reference image and a respective neighboring image and merging the separate motion class segmentation maps into a unified motion class segmentation map for the reference image.

Claim 7 (original): The method of claim 6, wherein reference image pixels are respectively assigned to a motion class selected from a motion class set including a high motion class and a low motion class, and motion vectors assigned to the high motion class have higher magnitudes than motion vectors assigned to the low motion class.

Claim 8 (original): The method of claim 7, wherein merging the separate motion class segmentation maps comprises

assigning a given reference image pixel to the low motion class in the unified motion class segmentation map when the given pixel is assigned to the low motion class in all of the separate motion class segmentation maps, and

assigning a given reference image pixel to the high motion class in the unified motion class segmentation map when the given pixel is assigned to the high motion class in any of the separate motion class segmentation maps.

Claim 9 (original): The method of claim 8, wherein the motion class set further includes an intermediate motion class, and motion vectors assigned to the intermediate motion class have magnitudes higher than motion vectors assigned to the low motion class and lower than motion vectors assigned to the high motion class.

Claim 10 (original): The method of claim 9, wherein merging the separate motion class segmentation maps comprises assigning a given reference image pixel to the intermediate motion class in the unified motion class segmentation map when the given pixel is unassigned to the high motion class in any of the separate motion class segmentation maps and is unassigned to the low motion class in all of the separate motion class segmentation maps.

Claim 11 (original): The method of claim 1, further comprising computing an alignment accuracy map for each pairing of the reference image and a respective neighboring image based on the computed motion maps.

Claim 12 (original): The method of claim 11, wherein computing alignment accuracy maps comprises re-mapping neighboring images to a coordinate frame of the reference image using respective motion maps, and computing correlation measures between pixels of the reference image and pixels of each of the motion-compensated neighboring images.

Claim 13 (original): The method of claim 11, further comprising up-projecting the computed alignment accuracy maps from the base image resolution level to the target image resolution level.

Claim 14 (original): The method of claim 13, further comprising up-projecting the motion maps from the base image resolution level to the target image resolution level, and classifying motion vectors in each up-projected motion map into valid and invalid motion vector classes based on the up-projected alignment accuracy maps.

Claim 15 (original): The method of claim 14, wherein values of target image pixels with corresponding pixels in all neighboring images being associated with motion vectors in the invalid motion vector class are computed by interpolating up-projected pixel values of the reference image.

Claim 16 (original): The method of claim 1, further comprising up-projecting the motion maps from the base image resolution level to the target image resolution level.

Claim 17 (original): The method of claim 16, further comprising re-mapping the neighboring images to the reference frame of the up-projected reference image using the respective up-projected motion maps.

Claim 18 (original): The method of claim 1, wherein regions of the target image are respectively assigned to a motion class selected from a motion class set including a high motion class and a low motion class, and motion vectors of regions assigned to the high motion class have higher magnitudes than motion vectors of regions assigned to the low motion class.

Claim 19 (original): The method of claim 18, wherein computing target image pixel values in regions assigned to the high motion class comprises computing a pixel-wise combination of pixel value contributions from the up-projected reference image and the re-mapped neighboring images weighted based on pixel-wise measures of alignment accuracy between the reference image and the corresponding neighboring images.

Claim 20 (original): The method of claim 19, wherein pixel value contributions from the re-mapped neighboring images are additionally weighted based on measures of temporal distance between the reference image and the corresponding neighboring images.

Claim 21 (original): The method of claim 18, wherein computing target image pixel values in regions assigned to the low motion class comprises classifying low motion class reference image pixels and their corresponding pixels in the neighboring images based on measures of local texture richness.

Claim 22 (original): The method of claim 21, wherein low motion class reference image pixels and their corresponding pixels in the neighboring images are quantitatively evaluated for local texture richness, and are classified into a texture class selected from the texture class set including a high texture region class and a low texture region class, and pixels assigned to the high texture region class have higher local texture measures than pixels assigned to the low texture region class.

Claim 23 (original): The method of claim 22, wherein values of target image pixels classified into the low texture region class in the reference image and all of the respective neighboring images, are computed by interpolating up-projected pixel values of the reference image.

Claim 24 (original): The method of claim 22, wherein a value of a given target image pixel classified into the high texture region class in the reference image or any respective neighboring images is computed based on a pixel value contribution from the up-projected reference image, and a pixel value contribution from a given re-mapped neighboring image weighted based on a measure of local texture richness computed for the given pixel, a measure of motion estimation accuracy computed for the given pixel , and a measure of temporal distance of the neighboring image from the reference image.

Claim 25 (original): The method of claim 18, wherein values of target image pixels are computed based on pixel value contributions from a number of base images neighboring the reference image, the number of neighboring base images being different for different motion classes.

Claim 26 (original): The method of claim 25, wherein values of target image pixels assigned to the high motion class are computed based on pixel value contributions from a fewer number of neighboring base images than the values of target image pixels assigned to the low motion class.

Claim 27 (original): The method of claim 26, wherein the motion class set further includes an intermediate motion class, the motion vectors of regions assigned to the intermediate motion class have lower magnitudes than motion vectors of regions assigned to the high motion class and higher magnitudes than motion vectors of regions assigned to the low motion class, and values of target image pixels assigned to the intermediate motion class are computed based on pixel value contributions from a fewer number of neighboring base images than the values of target image pixels assigned to the low motion class but a higher

number of neighboring base images than the values of target image pixels assigned to the high motion class.

Claim 28 (previously presented): An image processing machine, comprising:

a computer-readable memory storing computer process instructions; and

a computer processor operable to execute the computer process instructions and perform operations comprising

computing a respective motion map for each pairing of a reference image and a respective image neighboring the reference image in a sequence of base images, each motion map comprising a set of motion vectors mapping reference image pixels to respective neighboring image pixels at sub-pixel accuracy,

assigning respective regions of a target image to motion classes based on the computed motion maps, the target image having a target resolution level and the base images having a base resolution level equal to or lower than the target resolution level, and

computing pixel values for the target image based on corresponding pixel value contributions from the re-mapped base images selected in accordance with the motion classes assigned to the target image regions.

Claim 29 (previously presented): The machine of claim 28, wherein the computer processor is operable to assign regions of the target image to motion classes by assigning pixels of the reference image to respective motion classes and up-projecting the motion class assignments to pixels of the target image.

Claim 30 (previously presented): The machine of claim 29, wherein the computer processor is operable to assign reference image pixels to motion classes by computing motion magnitude maps from each motion map, down-sampling the computed motion magnitude maps to a pyramid of motion magnitude maps at respective resolution levels lower than the base resolution level, and segmenting pixels in the pyramid of down-sampled motion magnitude maps into motion classes.

Claim 31 (previously presented): The machine of claim 29, wherein the computer processor is operable to assign reference image pixels to motion classes by generating a

separate motion class segmentation map for each pairing of the reference image and a respective neighboring image and merging the separate motion class segmentation maps into a unified motion class segmentation map for the reference image.

Claim 32 (previously presented): The machine of claim 28, wherein the computer processor is operable to compute an alignment accuracy map for each pairing of the reference image and a respective neighboring image based on the computed motion maps.

Claim 33 (previously presented): The machine of claim 32, wherein the computer processor is operable to compute alignment accuracy maps by re-mapped neighboring images to a coordinate frame of the reference image using respective motion maps, and computing correlation measures between pixels of the reference image and pixels of each of the motion-compensated neighboring images.

Claim 34 (previously presented): The machine of claim 33, wherein the computer processor is operable to up-project the computed alignment accuracy maps from the base image resolution level to the target image resolution level.

Claim 35 (previously presented): The machine of claim 34, wherein the computer processor is operable to up-project the motion maps from the base image resolution level to the target image resolution level, and classify motion vectors in each up-projected motion map into valid and invalid motion vector classes based on the respective up-projected alignment accuracy maps.

Claim 36 (original): The machine of claim 35, wherein values of target image pixels with corresponding pixels in all neighboring images being associated with motion vectors in the invalid motion vector class are computed by interpolating up-projected pixel values of the reference image.

Claim 37 (previously presented): The machine of claim 28, wherein the computer processor is operable to up-project the motion maps from the base image resolution level to

the target image resolution level, and re-map the neighboring images to the reference frame of the up-projected reference image using the respective up-projected motion maps.

Claim 38 (previously presented): The machine of claim 28, wherein:

regions of the target image are respectively assigned to a motion class selected from a motion class set including a high motion class and a low motion class, and motion vectors assigned to the high motion class have higher magnitudes than motion vectors assigned to the low motion class; and

the computer processor is operable to compute target image pixel values in regions assigned to the high motion class by computing a pixel-wise combination of pixel value contributions from the up-projected reference image and the respective re-mapped neighboring images weighted based on pixel-wise measures of alignment accuracy between the reference image and the corresponding neighboring images.

Claim 39 (original): The machine of claim 38, wherein pixel value contributions from the re-mapped neighboring images are additionally weighted based on measures of temporal distance between the reference image and the corresponding neighboring images.

Claim 40 (previously presented): The machine of claim 38, wherein the computer processor is operable to compute target image pixel values in regions assigned to the low motion class based on classification of low motion class reference image pixels and corresponding pixels in the neighboring images based on measures of local texture richness.

Claim 41 (original): The machine of claim 28, wherein values of target image pixels are computed based on pixel value contributions from a number of re-mapped base images neighboring the reference image, the number of neighboring base images being different for different motion classes.

Claim 42 (previously presented): A computer-readable medium storing computer-readable instructions operable to cause a computer to perform operations comprising:

computing a respective motion map for each pairing of a reference image and a respective image neighboring the reference image in a sequence of base images, each motion

map comprising a set of motion vectors mapping reference image pixels to respective neighboring image pixels at sub-pixel accuracy;

assigning respective regions of a target image to motion classes based on the computed motion maps, the target image having a target resolution level and the base images having a base resolution level equal to or lower than the target resolution level; and

computing pixel values for the target image based on corresponding pixel value contributions from the re-mapped base images selected in accordance with the motion classes assigned to the target image regions.

Claim 43 (previously presented): The computer-readable medium of claim 42, wherein the computer-readable instructions are operable to cause the computer to assign regions of the target image to motion classes by assigning pixels of the reference image to respective motion classes and up-projecting the motion class assignments to pixels of the target image.

Claim 44 (previously presented): The computer-readable medium of claim 43, wherein the computer-readable instructions are operable to cause the computer to assign reference image pixels to motion classes by computing motion magnitude maps from each motion map, down-sampling the computed motion magnitude maps to a pyramid of motion magnitude maps at respective resolution levels lower than the base resolution level, and segmenting pixels in the pyramid of down-sampled motion magnitude maps into motion classes.

Claim 45 (previously presented): The computer-readable medium of claim 43, wherein the computer-readable instructions are operable to cause the computer to assign reference image pixels to motion classes by generating a separate motion class segmentation map for each pairing of the reference image and a respective neighboring image and merging the separate motion class segmentation maps into a unified motion class segmentation map for the reference image.

Claim 46 (previously presented): The computer-readable medium of claim 42, wherein the computer-readable instructions are operable to cause the computer to compute an

alignment accuracy map for each pairing of the reference image and a respective neighboring image based on the computed motion maps.

Claim 47 (previously presented): The computer-readable medium of claim 46, wherein the computer-readable instructions are operable to cause the computer to compute alignment accuracy maps by re-mapping neighboring images to a coordinate frame of the reference image using respective motion maps, and computing correlation measures between pixels of the reference image and pixels of each of the motion-compensated neighboring images.

Claim 48 (previously presented): The computer-readable medium of claim 47, wherein the computer-readable instructions are operable to cause the computer to up-project the computed alignment accuracy maps from the base image resolution level to the target image resolution level.

Claim 49 (previously presented): The computer-readable medium of claim 48, wherein the computer-readable instructions are operable to cause the computer to up-project the motion maps from the base image resolution level to the target image resolution level, and classify motion vectors in each up-projected motion map into valid and invalid motion vector classes based on the respective up-projected alignment accuracy maps.

Claim 50 (previously presented): The computer-readable medium of claim 49, wherein values of target image pixels with corresponding pixels in all neighboring images being associated with motion vectors in the invalid motion vector class are computed by interpolating up-projected pixel values of the reference image.

Claim 51 (previously presented): The computer-readable medium of claim 42, wherein the computer-readable instructions are operable to cause the computer to up-project the motion maps from the base image resolution level to the target image resolution level, and re-map the neighboring images to the reference frame of the up-projected reference image using the respective up-projected motion maps.

Claim 52 (previously presented): The computer-readable medium of claim 42, wherein:

regions of the target image are respectively assigned to a motion class selected from a motion class set including a high motion class and a low motion class, and motion vectors assigned to the high motion class have higher magnitudes than motion vectors assigned to the low motion class; and

the computer-readable instructions are operable to cause the computer to compute target image pixel values in regions assigned to the high motion class by computing a pixel-wise combination of pixel value contributions from the re-mapped neighboring images weighted based on pixel-wise measures of alignment accuracy between the reference image and the corresponding neighboring images.

Claim 53 (previously presented): The computer-readable medium of claim 52, wherein pixel value contributions from the re-mapped neighboring images are additionally weighted based on measures of temporal distance between the reference image and the corresponding neighboring images.

Claim 54 (previously presented): The computer-readable medium of claim 52, wherein the computer-readable instructions are operable to cause the computer to compute target image pixel values in regions assigned to the low motion class based on classification of low motion class reference image pixels and corresponding pixels in the neighboring images based on measures of local texture richness.

Claim 55 (previously presented): The computer-readable medium of claim 42, wherein values of target image pixels are computed based on pixel value contributions from a number of re-mapped base images neighboring the reference image, the number of re-mapped neighboring base images being different for different motion classes.

EVIDENCE APPENDIX

There is no evidence submitted pursuant to 37 CFR §§ 1.130, 1.131, or 1.132 or any other evidence entered by the Examiner and relied upon by Appellant in the pending appeal. Therefore, no copies are required under 37 CFR § 41.37(c)(1)(ix) in the pending appeal.

RELATED PROCEEDINGS APPENDIX

Appellant is not aware of any decisions rendered by a court or the Board that will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal. Therefore, no copies are required under 37 CFR § 41.37(c)(1)(x) in the pending appeal.